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Box 9.

BY PROF. H. KNAPP, M.D.,

Surgeon in Chief to the New York Ophthalmic and Aural Institute.

Reprinted from the Archives of Ophthalmology and Otology, I., 2, 1870.

NEW YORK:

WILLIAM WOOD & COMPANY,

61 WALKER STREET.

1870.

PURULENT OTITIS MEDIA, CAUSED BY THE NASAL DOUCHE, AND ACCOMPANIED BY DOUBLE HEAIRNG.

BY H. KNAPP.

THE use of *Weber's* nasal douche for diseases of the naso-pharyngeal region has of late become very extensive. Some recent publications, however, show that it is not without serious danger. Dr. *D. B. St. John Roosa* describes in the first number of these Archives (p. 259, etc.) a case in which the origin of a purulent inflammation of the middle ear, of the very severest kind, could be traced to the use of the nasal douche. He adds that he had observed other cases in which the nasal douche was followed by bad symptoms, and that it hardly ever could be tolerated for any length of time. *S. Moos*, in a note to the German translation of Roosa's communication, confirms these views by stating that he saw the fluid which had been injected into the nostril by Weber's douche, flow out of the ears in two cases of perforation of the drum-head. Although the application of the douche is not hurtful in such cases, they prove that

water thus introduced into the posterior nasal space may penetrate through the Eustachian tubes into the tympanic cavity. Moos, too, saw a case in which an acute aural catarrh was brought about by the nasal douche. The practical importance of these observations induces me to communicate a case of a similar kind :—

A merchant of New York, 32 years of age, was in the habit of injecting, by Weber's douche, warm water into his nose for chronic catarrh. He once took *cold water*, and felt, immediately after the injection, considerable pain in both ears, disappearing, however, very soon. Since that time he used warm water for six months without any unpleasant symptoms. Then he employed cold water once again, and experienced instantly in his left ear a severe pain, which soon abated, but nevertheless continued dull and annoying for a fortnight. Then suddenly it increased very much, was combined with headache, throbbing in the ear, loss of appetite, and deafness. Three days later an abundant purulent discharge from the left ear set in. He came to my office presenting all the symptoms of a very severe otitis media, with perforation of the membrana tympani. He remained under my treatment from March 6th to April 11th. Three weeks after his first call a great improvement had been obtained, the discharge was stopped, and the perforation in the drum-head closed for four days. Then an exacerbation and a new perforation occurred. The discharge kept flowing for a fortnight, when again an improvement was obtained, and the patient left New York to complete his recovery under the care of his father, a physician in the neighborhood of Philadelphia.

There is no doubt that the purulent inflammation of the middle ear was caused by the flowing of *cold* water into the tympanic cavity. Whether warm water sometimes or usually passed into the drum during the use of Weber's douche cannot be ascertained, since the patient

never felt it. I am satisfied that water can penetrate into the drum only when the patient accidentally swallows during the time the current is running over the orifices of the Eustachian tubes. It is easily explainable that cold water is more apt to provoke involuntary swallowing than warm. Moreover, the latter, when passing into the tympanum, would probably not cause much reaction or bad consequences. It therefore is certainly less objectionable than the use of cold water in cleansing the nasal and upper pharyngeal region. Since the observation above related, and the communications of *Roosa* and *Moos*, I have not recommended any more the use of the nasal douche, but applied injections of astringent remedies by the posterior nares syringe. They are disagreeable for a great many patients, producing very unpleasant fits of sneezing and coughing, but their action is efficient, and, as it seems, devoid of danger. If we inject only small quantities of fluid, which is mostly sufficient, there is commonly no unpleasant reaction.

Besides its origin, the above case was very remarkable for a symptom not much noticed yet, viz., *double hearing with both ears.* *Tröltsch* and *Politzer* mention its occurrence only with two lines; *Moos* records in his "Klinik der Ohrenkrankheiten," p. 319, etc., what is known on it. There are three incomplete observations in older literature, to which are added two of *Moos* himself, and one of *Von Wittich.* The first of Moos' patients, suffering from acute aural catarrh, heard simultaneously the third of each tone he was singing. The catarrh and double

hearing disappeared both together very soon. The second patient had impairment of hearing from chronic aural catarrh for ten years. One evening, to shorten a fit of his habitual asthma, he anæsthetized himself by chloroform. On awaking his deafness was very much worse, and he heard all the sounds of the upper three octaves of a piano double. During the course of some months his hearing power diminished still further, the double hearing continued for some time, and ultimately all musical sounds appeared to him so perverse that music in general, which he had been very fond of before, became a perfect horror to him. In none of these two cases mention is made which ear perceived rightly the natural tone, nor whether the pseudo-tone was higher or lower in pitch. The only well-analyzed case of the few cases of double hearing which are on record up to this day, is the observation made by Prof. *Von Wittich* on himself. The excellent physiologist of Koenigsberg noticed, four weeks after an acute purulent otitis media, that he heard *all the tones of the middle octave of a piano half a note higher* with the diseased ear than with the healthy one. His explanation is, that an exudation into the tympanic cavity, by altering the pressure of the fluid in the labyrinth, had changed the tuning of the terminal fibres of the auditory nerve.

When I examined the patient whose history I have sketched above, three days after the discharge had set in, I found in the diseased ear the hearing power for noises very much diminished (a watch of 6′ hearing

distance was heard from $\frac{1}{2}''$), whilst musical sounds were nearly as sharply perceived as in the normal state. A large tuning-fork, placed on the glabella, was *heard double, and in the affected ear more strongly and about two tones higher than in the sound ear.* On trial with a piano I found out that the same anomaly existed for the tones of the middle and next higher octaves, but not for the deeper ones. It was not distinctly marked at which note of the musical scale the double hearing began, nor where it terminated. This anomaly existed unchanged during the first week, as long as the perforation of the membrana tympani was large and the discharge abundant. Then the double sounds gradually came nearer to each other in pitch, until, at the end of three weeks, they hardly differed by half a tone, and sometimes were heard separately only by strained attention. After the relapse the double hearing was again a little better perceived, but the two tones never differed so much as in the beginning; moreover, their difference in pitch was changing from day to day. I have not heard of the patient since he left New York.

This observation has many features in common with that of *Von Wittich*, above all, the origin of the anomaly in an acute purulent otitis media. The principal differences of both cases are the following: 1st. The pseudo-tone (that of the diseased ear) was higher in Wittich's, lower in mine, than the right tone. 2d. The difference of pitch between real and pseudo-tone was greater in my case than in Wittich's. 3d. The differ-

ence of pitch between both tones was changing in my case, but constant in that of *Von Wittich.*

I shall try to account for these differences, together with giving an explanation of the whole anomaly. The latter is most appropriately termed *diplacusis binauricularis*, in analogy with a similar anomaly of the organ of sight, viz., diplopia binocularis. *Helmholtz's* theory is perfectly adapted to explain binauricular diplacusis. In conformity with this theory we may compare the cochlear portion of the inner ear with a stringed instrument. Corti's arcs or fibres—the strings—are so tuned as to yield all the sounds of the musical scale. Both cochleæ represent two instruments in perfect accord. If a sound is produced in the air, the vibrations of the latter will be transmitted through both membranæ tympani and the chain of the ossicles to those strings of Corti's organ which are tuned for this sound, and thus sympathetic vibrations are occasioned in Corti's fibres, and conveyed to the brain by the filaments of the auditory nerve connected with the vibrating fibres of Corti's organ. The same external sound will excite in either cochlea corresponding (identical) acoustic nerve fibres by producing sympathetic vibrations in corresponding (identical) arcs of Corti's organ. In analogy with similar conditions of both retinæ, *those fibres of both cochleæ may be called corresponding or identical, the simultaneous and equivalent excitement of which generates but* ONE *sensation of sound.* This constitutes the anatomical and physiological foundation of single hearing with both

ears, in a similar manner as we see single with both eyes.

Now, suppose the strings of one instrument (Corti's organ) are tighter drawn, then this instrument will be differently, that is, higher tuned, so that a string which formerly made f. i. 300 vibrations per second now makes 350 per second. Say 300 vibrations per second correspond to the tone *c*, 350 to the tone *e*. If, now, the latter tone, *e*, is sounded at any musical instrument, it will excite sympathetic movements in all strings so tuned as to perform 350 vibrations per second. (I may disregard entirely the harmonics.) In the healthy ear this will be Corti's fibre corresponding to the sound *e*, but in the diseased ear 350 vibrations are now performed by a fibre which formerly performed only 300 per second, and which, of course, is still connected with that auditory nerve-fibre which always committed the impression of 300 vibrations, that is, the tone *c*, to the brain. Therefore this ear will engender the perception of the lower sound *c*, whilst at the same time the other one will engender the perception of the higher sound *e*. Such were about the conditions in the case of double hearing observed by me.

The opposite state must have been present in *Von Wittich's* case. He heard with the diseased ear the tone higher than with the healthy one. Suppose he heard with the latter the sound *c* (300 vibrations per second), and with the diseased the sound *d* (say 325 vibrations per second), then Corti's fibre, tuned in the healthy state

to 325 vibrations, must have been so much relaxed that it now made only 300 per second. An external sound, *c*, of 300 vibrations per second, will induce sympathetic vibrations in that of Corti's arc of either ear which is tuned to 300 vibrations. In the healthy ear the right sound *c* is perceived, but in the diseased ear the relaxed arc will continue to excite the auditory fibre which always conducted the impression of 325 vibrations per second, that is, of the sound *d*, to the brain. *Von Wittich* made a very ingenious experiment to confirm this theory. If two tuning-forks, differing in pitch by half a tone, were so put before the ears that the lower one was before the diseased, the higher before the healthy ear, only one sound was perceived. The tuning-fork which yielded a lower sound produced sympathetic undulations in the relaxed Corti's arc which formerly was tuned half a tone higher, and now the nerve connected with it is excited with its corresponding nerve in the other cochlea.

Thus it is evident that diplacusis binauricularis may be of two kinds, by *false higher tuning*, *tightening*, and by *false lower tuning*, *relaxing*, *of Corti's organ. In the latter the pseudo-tone will be higher*, *in the former it will be lower*, *than the right tone.*

The greater the difference in pitch, the greater will be the degree of false tuning, *either by increased tension or by relaxation of Corti's organ.* This principle explains the second and third points of difference between my case and that of *Von Wittich*. There was, at the beginning of my observation, a morbid action on the cochlea

about four times as intense as in Von Wittich's case. This morbid action, however, was not constant during the course of my observation, but decreased in proportion with the decreasing intensity of the inflammation. It was scarcely yet perceptible when the discharge had stopped and the perforation of the drum-head was closed. In a case of Dr. *Gumpert* (see *Moos*, l. c., p. 319) the difference of pitch of both sounds varied between a third, fourth, and octave during one week, and then disappeared entirely.

Of what nature the changes are which produce false tuning of Corti's organ, I am not at all prepared to answer. *Von Wittich* assumes that exudation into the tympanic cavity changes the pressure of the fluid in the labyrinth. In his case the membrana tympani seems to have been entire at the time when diplacusis was noticed, for he adds that neither filling of the auditory canal with water, nor inflation of the tympanum with air, produced any alteration in the double hearing. In my case diplacusis of opposite kind existed, with perforation of the membrana tympani. Is the integrity of the membrana tympani essential in relaxing Corti's organ? Does its perforation produce tightening of it? I am unable to answer these questions. The first of *Moos*' cases, acute aural catarrh, seems to be analogous with Wittich's observation. "The patient heard simultaneously the third of every tone." If here, what is not stated, but seems to be understood, the third was the pseudo-tone, then there existed, like in Wittich's observation, dipla-

cusis by relaxation of Corti's organ. The drum-head was not ruptured.

The other observation of *Moos*, where diplacusis was occasioned by anæsthetizing with chloroform in a case of chronic aural catarrh, seems to be an example of idiopathic false tuning of Corti's organ, that is, not dependent on inflammatory changes in the middle ear. I think that, for the present, it is of greater importance to collect more facts relative to this anomaly than to seek for a theory.

The symptom of double hearing, when further studied, may be not only of physiological significance, but assume practical importance. It may guide our prognosis and treatment, by demonstrating that in the respective cases the labyrinth is either primarily affected or participates in some other disease. I suppose also that diplacusis binauricularis will be more frequently noticed than has been the case hitherto, if our attention be directed to it. With regard to future investigations, I propose that our inquiries should try to solve the following questions:—

1. How great is the *difference of pitch* between the two sounds?

2. Has the *pseudo-tone the same intensity and clang-tint* (timbre) as the right tone (that of the healthy ear)?

3. Are these *differences constant or varying* during the duration of the anomaly?

4. Is the *pseudo-tone higher or lower than the right tone* (diplacusis by relaxation or tension of Corti's fibres)?

5. Is it possible to *obtain single hearing* by producing tones of different pitch before either ear? The tuning-fork placed before the diseased ear ought to differ so much in pitch from the tuning-fork placed before the healthy ear as the pseudo-tone differs from the right tone, but the difference in pitch must be of opposite direction, f. i., if the pseudo-tone is half a tone higher than the right tone, then the tuning-fork placed before the diseased ear must be half a tone lower than that before the healthy ear. If the pseudo-tone is lower than the right tone, then the tuning-fork before the diseased ear must be so much lower.

6. At which heights of the musical scale does double hearing begin and terminate, that is, *how great is the range of double hearing?*

7. Are the *limits*, on the musical scale, *between single and double hearing distinct or fading away gradually?*

8. If the entire Corti's organ of one ear be differently tuned from that of the other ear, compound tones and pure chords must appear dissonant in binauricular, but consonant in monauricular hearing, also when in the latter case the healthy ear is excluded from the act of hearing. But if only a part of Corti's organ of one ear be differently tuned from the corresponding part of the other ear, all compound tones and the purest chords must appear dissonant in monauricular as well as in binauricular audition. All music must be a horrible dissonance, as in the one of *Moos'* cases. The examination has to determine of *what kind these dissonances in monauricular*

and binauricular audition are, which will be possible by analyzing the anomaly according to Helmholtz's theory.

9. What is the *cause of diplacusis?* Is the latter dependent on a primary lesion of the labyrinth, or consequent to morbid processes in the middle ear? In what state is the membrana tympani? Is there any change in intra-auricular pressure?

A complete investigation of this kind may, at first, be fraught with difficulties, and perhaps deemed resultless; but let me remind the reader that diplopia, not long ago, was an abstruse subject too, which has now become most valuable with regard to diagnosis, prognosis, and treatment of a large group of eye-diseases.

THE INFLUENCE OF SPECTACLES ON THE OPTICAL CONSTANTS AND VISUAL ACUTENESS OF THE EYE.

By H. KNAPP.

(A.) INFLUENCE OF SPECTACLES ON THE ORDINARY EYE.

Every oculist at the present day is fully convinced that an accurate determination of the acuteness of vision (S) is of the greatest importance in the practice of ophthalmology. The older methods are now all given up in favor of ascertaining S by a rational system of test-types. In cases of anomalous refraction, S is found out by means of convex or concave glasses neutralizing the anomaly of refraction. That, in doing so, a certain degree of inaccuracy is introduced by disregarding the magnifying and diminishing influence of these glasses is evident, but the amount of this inaccuracy has not yet been calculated. Even *Donders*, in his very exhaustive treatise on the Anomalies of Accommodation and Refraction, does not touch this question. He says (p. 152) that, without further determination, a comparison of THE VISUAL ANGLES can only be made if the

visual object can be accurately seen *with or without auxiliary glasses.*

I purpose now to examine what influence on the visual acuteness these auxiliary glasses exert in ametropic eyes.

It is known that ametropia is caused not by any notable changes in the refracting media and their surfaces of separation, but by changes of position of the retina. Therefore we may assume that the optical constants of ametropic eyes are equal to those of emmetropic ones. I shall take as a basis for the calculation the values of *Listing's diagrammatic eye* given in most text-books, for instance, *Helmholtz's* Physiological Optics, p. 111, and *Donders'* Accom. and Refraction, p. 67. (In the latter there is a misprint: line 7 from the bottom of the page, anterior focal distance of the eye ought to be 14,858 instead of 19,875.)

To solve the problem in a general way, I shall calculate the optical constants of a compound dioptrical system, consisting of the normal (or diagrammatical) eye combined with the series of our common spectacle-glasses. This work has not yet been done, and may also prove useful in solving other questions relating to vision through lenses.

In the calculations I shall avail myself of the convenient formulas given in *Helmholtz's "Physiologische Optik."*

The usual distance at which spectacles are worn before the eye is about half a Paris inch. We may, therefore, place the auxiliary lens 14,858 mm. in front of the first principal plane of the eye. It is sufficiently accurate for

our present purpose to disregard the thickness of the glass lens, its two principal and focal points falling together and coinciding with the so-called optical centre. By placing the glass 14,858 mm. before the first principal plane of the eye, the optical centre of the first system coincides with the first focal point of the second system, the anterior focal length of the latter being 14,858 mm.

These suppositions made, we can proceed to *determine the position of the cardinal points of the compound system.*

f_1 and f_2 denote the first and second focal lengths* of the first system, which, being equal, may indiscriminately be represented by f.

ϕ_1 and ϕ_2 denote the first and second focal lengths of the second system, the eye;

And d the distance between the optical centre of the glass lens and the first principal plane of the eye.

$$d = 14{,}858 = \phi_1.$$

We find $a_1\, t_1$, viz., the distance of the first focal point of the compound system *in front* of the optical centre of the auxiliary lens by Helmholtz's formula 11a (l. c., p. 56).

$$a_1\, t_1 = \frac{(d - \phi_1)\, f_1}{d - \phi_1 - f_2}$$

d being equal to ϕ_1 and $d - \phi_1 = 0$, we therefore obtain $a_1\, t_1 = 0$,

* For the sake of simplicity of expression, I mean, in conformity with modern German opticians, by *focal length* always *principal focal length*, thus distinguishing it sufficiently from conjugate focal length or distance.

which signifies *that the anterior focal point of the compound system coincides with the anterior focal point of the eye.* This result is valid both for positive and negative glasses.

Formula 11*b*,

$$\alpha_2 \tau_2 = \frac{(d - f_2)\, \phi_2}{d - \phi_1 - f_2}$$

determines the position of the *second focal point of the compound system behind the second principal point of the eye.*

Let us illustrate the calculation by an example, say lenses No. 10, convex and concave, viz.: lenses with 270,6995 mm. of positive and negative focal lengths. By substituting the proper values, the preceding formula results in

$$\alpha_2 \tau_2 = \frac{(14{,}858 - 270{,}6995)\ 19{,}875}{-\ 270{,}6995} = 18{,}784 \text{ mm. for}$$

$+ 10''$,

and

$$\alpha_2 \tau_2 = \frac{(14{,}858 + 270{,}6995)\ 19{,}875}{270{,}6995} = 20{,}966 \text{ mm. for}$$

$— 10''$.

Both these values, being positive, indicate the situation of the posterior focal point of the compound system *behind* the posterior principal point of the eye.

I shall now proceed to determine the *principal points of the compound system.*

Formula 11*d* (Helmholtz, l. c., p. 57)

$$h_1 = \frac{d\,f_1}{d - \phi_1 - f_2}$$

determines the *position of the first principal point of the compound system in front of the first principal point of the first system.*

As $d - \phi_1 = o$, and $f_1 = f_2$, we obtain

$h_1 = -d.$

The same result is arrived at whether the auxiliary lens be positive or negative, since f_1 and f_2 will in either case have inverse signs, thus rendering the value of h_1 negative in both instances.

The negative sign before d means that the first principal point of the compound system does not lie *in front* of, but *behind* the first principal point of the glass lens. As we made $d = \phi_1$, it follows that *the first principal point of the compound system coincides with the first principal point of the eye.*

Formula 11*e* (ibidem, l. c.),

$$h_2 = \frac{d\,\phi_2}{d - \phi_1 - f_2},$$

determines the position of *the second principal point of the compound system behind the second principal point of the second system*; f_2 being assumed positive, that is a convex lens (+10) placed before the eye.

As $d - \phi_1 = o$, we obtain

$$h_2 = \frac{d\,\phi_2}{-f_2} = \frac{14{,}858 \times 19{,}875}{-270{,}700}$$

$$h_2 = -1{,}0909 \text{ mm.}$$

This result shows *that by placing a convex lens No.* 10

before the eye, the second principal point of the compound system falls 1,0909 *mm. in front of the second principal point of the eye.*—The distance between the two principal points of the eye being 0,4160 mm., this quantity subtracted from 1,0909 shows *the position of the second principal point of the compound system* 0,6749 *mm.* IN FRONT *of the first principal point of the compound system.*

We have determined above the position of the second focal point of the compound system to be 18,784 mm. behind the second principal point of the eye. To find the *second focal length*, which is the distance between the second principal point and the second focal point of the compound system, we must add 1,0909 mm. to 18,784 mm. Thus we obtain the second focal length of the compound system

$F_2 = 19{,}875$ mm., which is $= \phi_2$, the second focal length of the eye.

If we place a *negative lens* ($-10''$) before the eye, the second principal point is likewise obtained by formula 11*e*, with the difference only that f_2 being negative in this case, renders the value of h_2 positive, namely—

$$h_2 = \frac{d\,\phi_2}{d - \phi_1 + f_2} = 1{,}0909 \text{ mm.}$$

This shows that with negative glasses of the same focal length the second principal point recedes by the same quantity as it advances with positive glasses.

The second focal length of the compound system is,

therefore, obtained for concave glasses by subtracting this quantity from the value above found for $\alpha_2 \tau_2$, which expresses the distance between the second focal point of the compound system from the second principal point of the eye. Therefore,

$F_2 = 20{,}966 - 1{,}0909.$

$F_2 = 19{,}875$ mm. $= \phi_2$.

Thus we have found *that the second focal length, F_2, of the compound system proves equal to the second focal length of the naked eye, whether for convex or for concave glasses.*

The position of the *nodal points* is now easily ascertained, as, in every system, the distance of the first nodal from the first focal point is equal to the second focal length. All these quantities of the compound system having been found identical with the corresponding quantities of the naked eye, the first *nodal point of the compound system must also coincide with the first nodal point of the eye.*

The equality of the posterior focal length of the compound system with that of the eye, has been obtained only by numerical calculation of one example, and from it the position of the first nodal point has been deduced. As this may not be considered sufficient evidence, I shall demonstrate it in a general way.

Formula 11*d*,

$$h_1 = \frac{d\ f_1}{d - \phi_1 - f_2},$$

determines the position of the first principal point by the

distance (d) of the glass lens from the anterior principal point, moreover by the anterior focal length (ϕ_1) of the eye, and the focal length of the glass ($f_1 = f_2$). The position of the focal points of a compound dioptrical system may be determined independently from the principal points, by proceeding from the nodal points of the single systems in a similar way as by making use of the principal points. If d' signifies the distance between the second nodal point of the first system and the first nodal point of the second system, ϕ_2 the second focal length of the second system, and f_1 and f_2 the anterior and posterior focal lengths of the first system, the formula 11*d* is transformed into the following:

$$K_1 = \frac{d' f_1}{d' - \phi_2 - f_2}$$

in which K_1 represents the situation of the anterior nodal point of the compound system *in front* of the anterior nodal point of the first system.

$d' = \phi_2$ and $f_1 = f_2$, we obtain

$K_1 = - d' = \phi_2$, that is, the anterior nodal point of the compound system lies *behind* the optical centre of the glass lens by a quantity equal to the posterior focal length of the eye, and, therefore, coincides with the first nodal point of the eye. Since the anterior focal point of the compound system likewise coincides with the anterior focal point of the eye, it follows that the posterior focal length of the compound system equals the posterior focal length of the eye.

If, instead of a convex lens, we place a concave one before the eye, these results remain the same, for f_1 and f_2, which now are negative, enter into the above formula with inverse signs, consequently the value and situation of K_1 will not be influenced.

The distance between the two nodal points being always, in every simple or compound system whatsoever, equal to the distance of the two principal points, *the second nodal point of our compound system must assume the same position relative to the first nodal point, as the second principal point to the first principal point of the compound system.*

Since, lastly, the second focal length of the compound system is the distance between its second principal and second focal points, and is equal to the second focal length of the eye, it is evident that *the second focal point of the compound system takes the same relative position to the second focal point of the eye, as the second principal and nodal points of the compound system to the second principal and nodal points of the eye.*

If we recapitulate the foregoing investigations, we notice the following remarkable result:—

Spectacle-glasses, held half an inch before the eye, do not change the situation of its anterior cardinal points, nor its anterior and posterior focal lengths, but the situation of each of the posterior cardinal points is altered in such a manner that convex lenses make them advance, and concave glasses recede by the same quantity.

Having arrived at this conclusion, our practical calcu-

lations are very much simplified, and, indeed, reduced to the evaluation of the position of either the second principal or second nodal point. This indicates at the same time what change has taken place in the position of the posterior focal plane, that is, the retina, and, consequently, in *the length of the ocular axis.*

After having, in this way, determined the *optical constants* of a compound dioptrical system, consisting of *the human eye and spectacle-glasses*, we may now proceed to investigate *what influence the latter have on visual acuteness.*

The *sharpness of vision in the normal eye is dependent on the density of the percipient retinal elements.* We may fairly assume that the number of these percipient retinal elements, and of the optic-nerve fibres connected with them, is the same in all normal eyes. If, nevertheless, we find variations of S in different eyes which we must consider as normal, these variations result certainly more from deficiencies in the optical part of the eye than from varying numbers of percipient elements and optic nerve-fibres. In diseased eyes, where the optic nerve, retina, and choroid have suffered, the sharpness of vision sinks in proportion to the destruction of percipient elements. *According to general acceptance, S is measured by the smallest visual angle, that is, the deviation of two lines which connect the second nodal point of the eye with two adjoining percipient retinal elements.* Hence it follows that the visual angle, and with it S, will change whenever the distance between the second nodal point and the retina changes,

the latter itself undergoing no alteration of structure. Spectacles move, as we have seen, the second nodal point, and therefore change the visual angle; but only in a few instances, viz., in presbyopia, and if the effect of weak glasses is counterbalanced by accommodation, we have to deal with normal eyes. The eyes which require spectacles in order to see at distance clearly and with ease, that is, without any accommodative effort, are not normal, but either too long (myopia), or too short (hyperopia). Since, however, as we have said at the beginning, the refractive parts of these eyes are normal, the shortening or elongation of the ocular axis can only result from advancement or retrocession of the posterior portion of the ocular membranes. The retina of such eyes may be, and mostly is, as normal as in the emmetropic eye, and therefore must contain the same number of percipient

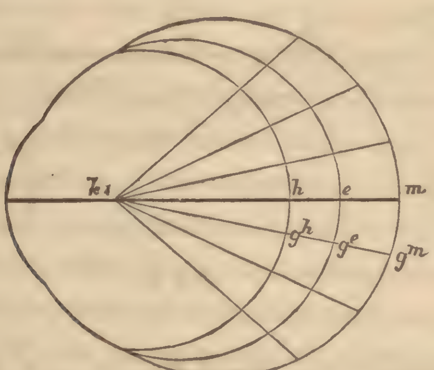

FIG. 1. ‡.

elements and nerve-fibres. The necessary consequence of this fact evidently is, that the absolute density of the

retinal elements is greater in short (hyperopic), and less in long (myopic), than in emmetropic eyes. In hyperopic eyes, the retinal surface, with all its elementary parts, may be considered as contracted, in myopic eyes, as expanded. If, in Fig. 1, the three curved lines represent a hyperopic, emmetropic, and myopic eye, the radii drawn from the anterior nodal point (k_1), will embrace between them corresponding portions of the retina, with equal numbers of percipient elements. The same number of the latter which exists in the normal eye must be distributed over a smaller surface in the hyperopic eye, and over a larger surface in the myopic eye.

Let us now see *what influence spectacles exert on visual acuity.* Fig. 2 will illustrate this very plainly. *A B*

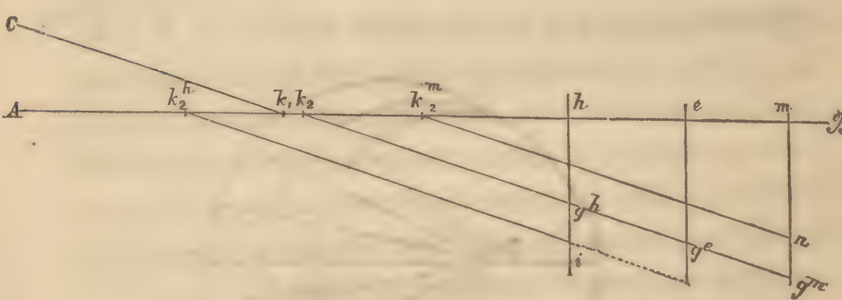

FIG. 2.

is to represent the visual line, k_1 and k_2^e the anterior and posterior nodal points, and *e* the intersection of the retina and the visual axis in the emmetropic eye. *h* and *m* are the points of intersection of the visual line and

retina, k_2^h and k_2^m the posterior nodal points in the hyperopic and myopic eyes, thus displaced by spectacles neutralizing the errors of refraction.

If the same object be looked at by each of the three eyes, it will appear under the same visual angle. This statement is at variance with the current opinion, that convex glasses, by advancing the nodal point, render the visual angle larger, and concave glasses render it smaller by making the nodal point recede. This would be true if both nodal points coincided, or were displaced, by spectacles in the same direction. In the naked eye they lie indeed close together, and during accommodative efforts their movements are homonymous, so that they may, for ordinary purposes, be regarded as coinciding. But for eyes armed with spectacles we are no longer allowed to make this concession, as I have shown above. Let, in Fig. 2, $A\,k_1$ represent the principal line of direction (principal axial ray of authors) of an object, Ck_1 a secondary line of direction (secondary axial ray), then the former will continue its course undeviated, while the latter will pass through the vitreous body parallel to its anterior portion (going through the air), but be displaced in such a way that the second nodal point (k_2^e) lies in the naked eye very little behind the first (k_1), further behind (k_2^m) in an eye armed with concave glasses, and in front of the second nodal point of the unarmed eye in eyes wearing convex glasses (k_2^h). If we consider (in Fig. 2) the different triangles which are formed by the primary and secondary lines of direction,

and the connecting lines of their crossing points in the retina, we see that all these triangles are similar to one another, and especially *the angles at k_2, the visual angles, are equal.*

When the *hyperopic eye* is not armed with spectacles, its retina, hi, is situate in front of its posterior focal plane, eg^e, but its posterior nodal point, k_2^e, lies in the normal place. The secondary visual line cuts off the portion hg^h of the retina. But when the hyperopic eye is armed with convex spectacles, the secondary nodal point advances (k_2^h), and the secondary axis cuts off, on the retina, a larger portion, hi, than it did before spectacles were added to the eye. The larger portion of retina must, of course, comprise a greater number of percipient elements. If we now admit that in Figs. 1 and 2 eg^e are two adjoining percipient elements of the retina, being approximated to each other, in the hyperopic eye, to the position hg^h, then we see that the addition of a convex glass causes, of the same object, a larger retinal image than the naked eye. If hg^h represents the extent of the smallest perceptible retinal image, say f. i. of No. xx. Snellen, seen at 20′ distance, the addition of a convex glass, increasing the retinal image of the same object to the extent of hi, would enable the same eye to distinguish at 20′ distance smaller type than No. xx. Sn. Thus we find its visual acuteness greater than $\frac{20}{xx}$, or $S > 1$. It is, therefore, evident that by wearing convex glasses the optical power of the eye increases, even if we leave out

of consideration the correction of the impurity of the retinal images.

Suppose somebody is able *to see at distance distinctly without and with convex glasses* (facultative hyperopia, *Donders*), then his eye, when unaided, would form the perfectly pure image hg^{h}, and, when armed with a convex glass, the image hi quite as distinctly, but larger, of the same object. Therefore the eye, when armed with convex glasses, would be able to read smaller type than Sn. xx. at 20′ distance, that is, his visual acuteness would be greater than normal, according to our usual method of testing.

Both nodal points advance in every eye by accommodation. By $A = \frac{1}{4}$ this advancement amounts to 0,4 to 0,5 mm., causing an adequate aggrandizement of the retinal images equivalent to that produced by convex spectacles No. 24, as the table further below demonstrates. In this way we are able to compare the aggrandizement of the image caused by accommodation in the unarmed hyperopic eye, with the aggrandizement of the image caused by convex glasses in the hyperopic eye. To determine how much the magnifying effect of convex glasses exceeds that produced by accommodation, we take the former in the table further below, and deduct from it the aggrandizement produced by accommodation. If, f. i., a patient with hyperopia $= \frac{1}{12}$ wishes to see clearly at distance without glasses, he must make an accommodative effort of $\frac{1}{12}$. But this is only the third part of $A = \frac{1}{4}$; the aggrandizement by accommodation, therefore,

is only one-third of that produced by a convex glass No. 24, or equivalent to that of + 72. We shall, hereafter, see that the magnifying effect of glasses weaker than No. 10 may fairly be neglected for practical purposes; so much the more may we disregard the influence of accommodation on the size of the retinal images. Apart from that, it is the object of the present investigation to evaluate the changes of size brought about by spectacles in the retinal images, making abstraction of the optical purity of the latter. In that way only we obtain a correct measure to compare the visual acuteness of armed ametropic eyes with that of the unarmed emmetropic eye; for spectacles re-establish the purity of the retinal images, and render accommodation equal to that of the emmetropic eye; but in doing so they moreover exert some influence on the size of the retinal image, and it is the amount and consequences of this accessory factor we are endeavoring here to ascertain. The foregoing lines, however, solve the problem raised by *Donders*, and quoted at the beginning of this paper, that a comparison of the visual angles can only be made, if the visual object can be accurately seen with or without auxiliary glasses. Instead of visual angles we would now say the size of the retinal images.

The conditions of *myopic eyes* are easier to analyze. The retina, mg^m, Figs. 1 and 2, being distended, displays a less density of its percipient elements. The line mg^m may be supposed, as I have shown, to contain no more percipient elements than eg^e or hg^h in the emmetropic

and hyperopic eyes. If, now, mg^m (Fig. 2) is the smallest perceptible retinal image of an unaided myopic eye, the addition of a concave glass would reduce this image of the same object to the size of mn, by shifting the second nodal point from k_2^e backward to k_2^m. The dimension mn being less than the distance of two adjoining percipient elements, or less than the smallest perceptible retinal image, the addition of a concave glass has rendered visual acuteness less than normal.

The amount of increase or diminution of visual acuteness brought about by spectacles is proportionate to the increase or diminution they produce in the retinal images. This amount may be estimated as follows:

(*A.*) *Calculation of the amount of increase of the retinal image, and, consequently, of visual acuteness by convex glasses.*

Let $hg^h = \beta_1$, Fig. 2, be the linear dimension of a smallest retinal image of an hyperopic eye, and $hi = \beta_2$, the retinal image of the same object in the same distance when looked at through a convex glass, then β_1 and β_2 constitute corresponding lines in two similar triangles, and are to each other as their distances from the corresponding nodal points. The quantity by which the second nodal point is shifted on the axes may be called $\delta = k_2^e\, k_2^h = k_2^e\, k_2^m$, then $\mathrm{hk}_2^e = \mathrm{F}_1 - \delta$, since the distance of the second nodal point of the compound system from the retina is equal to the first focal length of the eye, $\mathrm{hk}_2^h = \mathrm{F}_1$. We therefore obtain the following proportion:—

$\frac{\beta_2}{\beta_1} = \frac{F_1}{F_1 - \delta}$, from which is deduced

$\beta_2 = \frac{\beta_1 F_1}{F_1 - \delta}$.

If we give β_1 the standard value 1, we obtain

$\beta_2 = \frac{F_1}{F_1 - \delta}$ as the amount of β_2 with regard to β_1.

F_1 being 14,858 mm., and $\delta = 1,0909$ mm. (for + 10 as we saw above), we obtain

$\beta_2 = 1,0793$, *as the co-efficient of any retinal image, when* + 10 *is worn half an inch before the eye.*

If we measure visual acuteness by the smallest perceptible retinal image, and assume the hyperopic eye had S = 1, it will have S = 1,0793 when armed with + 10.

Since the linear dimension of the retinal image is in simple inverse proportion to the distance of the object, that is, decreases as the object is removed, Sn. xx. must be 1,0793 × 20′ = 21,580′ removed from an eye armed with + 10 in order to produce the smallest perceptible retinal image.

(*B.*) *Calculation of the amount of diminution of the retinal image, and, consequently, the visual acuteness, by concave glasses.* In the unaided myopic eye the second nodal point lies in the same place as in the emmetropic eye, k_2^e Fig. 2. Since the retina is distended proportionately to its retrocession, the retinal elements contained in the line eg^e of the emmetropic eye are distributed over the longer line mg^m of the myopic eye. The retrocession of the second nodal point from k_2^e to k_2^m, resulting from the ad-

dition of a concave glass before the eye, generates from the same object which in the unaided myopic eye produced the image mg^m, now the smaller image mn. The relation of magnitude of both these images is easy to ascertain. $m\,k_2^m$ is equal to $F_1 = 14{,}858$ mm., and $k_2^m\,k_2^e = \delta$ is the retrocession of the second nodal point, amounting for a glass of 10″ of negative focal distance to 1,0909 mm. If $mn = \beta^2$ and $mg^m = \beta_1$, the similarity of the respective triangles shows

$$\frac{\beta_2}{\beta_1} = \frac{F_1}{F_1 + \delta} = 0{,}9316,$$

which expresses the co-efficient of the diminishing power of concave 10″.

A myopic eye, armed with $-10''$, therefore, must be considered to possess normal acuteness of vision, if it is able to read Sn. xx. at $0{,}9316 \times 20' = 18{,}632'$.

I have disregarded, in the foregoing investigations, the appearance of dispersion circles, and was certainly justified to do so, because I founded the visual acuteness on the density of the percipient retinal elements and the *dimensions* of the retinal images, making abstraction of all imperfections of the latter. If an unaided ametropic eye looks, with relaxed accommodation, at a distant object, the centres of the dispersion circles from the end-points of the object will fall on the same retinal elements as in the emmetropic eye, as is illustrated in Fig. 2 ; g^h, g^e, and g^m are the same retinal elements, that is, they are separated from the central element of the fovea centralis (h, or e, or m) by an equal number of intermediate elements. If

$e\,g^e$ are two adjoining retinal elements, then hg^h and mg^m are likewise adjoining.

The addition of spectacles to the eye has the effect of shifting the second nodal point on the axis. Hence the images of all the object points, except the one situate in the axis, are displaced, namely, removed from the axis by convex glasses, approximated to it by concave glasses. Thus it is evident that convex glasses cause the image of an object to cover a greater number of percipient retinal elements than if the same object were seen without glasses, whilst the inverse obtains with concave glasses. I have shown already that it is erroneous to speak, as it is generally done, of an augmentation or diminution of the visual angle by spectacles, for the visual angle remains unchanged, if glasses are worn at the usual distance of half an inch from the eye.

I have now, in a general way, solved the problem to show what influence spectacles have on the optical constants of the eye, on the size of the retinal images, and on the acuteness of vision. I have, moreover, illustrated it by an example, No. 10 convex and concave.

To render these investigations useful for reference, I shall tabulate the results of calculation concerning the series of our test-glasses :—

Number of glass in Paris inches.	Displacement of 2d cardinal points in millimetres.	Co-efficient of magnifying effect of convex glass.	Co-efficient of diminishing effect of concave glass.	S being 1, No. xx. Sn. should be read with convex glass in Paris feet,	S = 1, No. xx. Sn. should be read with concave glass in Paris feet
30	0,3628	1,0250	0,9762	20,50	19,52
16	0,6812	1,0480	0,9562	20,96	19,12
10	1,0909	1,0793	0,9316	21,59	18,63
8	1,3636	1,1011	0,9159	22,02	18,32
7	1,5584	1,1171	0,9051	22,34	18,10
[6	1,8182	1,1396	0,8910	22,79	17,82
5	2,1818	1,1721	0,8720	23,44	17,44
4	2,7272	1,2248	0,8449	24,45	16,90
3½	3,1168	1,2655	0,8265	25,31	16,53
3	3,6363	1,3240	0,8034	26,48	16,07
2½	4,3636	1,4159	0,7738	28,32	15,48
2	5,4544	1,5800	0,7315	31,60	14,63
1¾	6,2499	1,7260	0,7078	34,52	14,08
1½	7,2914	1,9625	0,6708	39,25	13,42
1¼	8,2602	2,3044	0,6427	46,09	12,85
1	10,909	3,4878	0,5837	69,77	11,67

Remarks on the foregoing Table.

The displacement of the second cardinal points, that is, the second principal, nodal, and focal points, expresses at the same time the elongation or shortening of the ocular axis in degrees of ametropia corresponding to the number of the spectacle-glasses enumerated in the first column. The length of the ocular axis, that is, the distance between the apex of the cornea and the fovea centralis retinæ, in the normal eye, is 22,23 mm., according to *Listing's* diagram. We may, therefore, avail ourselves of this table to determine, with the ophthalmoscope or functional testing, the situation of any part of the fundus oculi with regard to the position of the posterior

focal plane. If, for instance, a tumor or a circumscribed exudation projects over the background of the eye, we have first to ascertain with which auxiliary glass, put behind the ophthalmoscope, we can see clearly, by relaxed accommodation and in the upright image, the background of the eye, and, secondly, with which other glass we can see the summit of the projection. The difference of both glasses will give the height of the elevation by referring to the first and second columns of our table. Since this evaluation is of importance in judging the existence and amount of any elevation or depression, as well as its augmentation or diminution during the course of the disease, I shall illustrate the manner of this ophthalmoscopic measurement by some examples.

1. In an emmetropic eye, the fundus of which an emmetropic observer sees distinctly without any auxiliary glass put behind the ophthalmoscope, and an ametropic observer with his neutralizing glass, there is a circumscribed exudation or tumor, the summit of which is distinctly seen in the erect image with all the convex glasses up to number 8, whilst with stronger glasses it appears indistinct. Then No. 8, the strongest convex glass with which the summit of the tumor appears distinct, indicates an elevation of the tumor by 1,36 mm. over the background of the eye, as is seen by the number of the second column of the above table corresponding to No. 8.*

* I have described this method of estimating the relief of the background of the eye at the meeting of the Société Universelle d'Ophthalmologie, Aug., 1867, in Paris, and given a table relating to it in my book on "Intraocular

2. The fundus oculi is seen with + 24 distinctly, the summit of a tumor with + 4. The height of the tumor is calculated as follows: $\frac{1}{4} - \frac{1}{24} = \frac{5}{24}$, or nearly $\frac{1}{5}$. No. 5 in the first column of the above table indicates, as seen in the second column, an elevation of 2,18 mm. over the level of the retina.

3. The fundus is seen distinctly with − 20; the summit of a tumor with + 10. $\frac{1}{10} + \frac{1}{20} = \frac{3}{20} = \frac{1}{6\frac{2}{3}}$ gives, with reference to columns the first and second, 1,66 mm. as the height of the tumor.

4. A hyperopic eye, the retina of which appears distinct with + 6, suffers from chronic glaucoma. The area of the optic disc appears plain with + 18. How deep is the excavation? $\frac{1}{6} - \frac{1}{18} = \frac{1}{6}$. Answer: 1,2 mm. This method of estimating elevations and depressions is especially valuable in the early stages of new growths and excavations, when the differential diagnosis and our judgment with regard to the progressiveness of the morbid action are apt to be difficult.

The *third and fourth columns* of the above table do not require much explanation. Each glass of the first column,

Tumors," p. 106. The numbers there were obtained by another way of calculation, and differ slightly from those given in this paper, because I took as basis of the former calculation the results of my own measurements on the living eye, whilst for the calculation of the present table the values of *Listing's* diagrammatic eye are taken as basis. I have here preferred *Listing's* values, although they are perhaps not so generally correct as those obtained on the living eye, because they are at the reach of everybody, and the difference between the two is unimportant. Dr. *Mauthner* also describes the measurement of the depth of the background of the eye in his Treatise on Ophthalmoscopy, Vienna, 1868. He gives some examples, but no table to refer to.

by displacing the second nodal point, produces a certain alteration of the size of the retinal images. This alteration is found by multiplying the linear dimensions of the retinal images with the corresponding numbers of the third and fourth columns. Therefore I have called them *co-efficients* of the magnifying or diminishing effect of spectacles.

The *fifth and sixth columns* need not much explication either. Snellen's test-types being so chosen that the size of the letters or the intervals between them produce, at the distance indicated by their numbers, the smallest perceptible retinal images, then by looking with spectacles, on account of their magnifying or diminishing power, the distances of the types from the eye must be changed, if the images are to remain the smallest possible for distinct perception. We find the requisite distance for each number of Snellen's test-types, and for each spectacle-glass, by multiplying the number of the type with the co-efficient of magnifying or diminishing power of the glass. This having been done for No. xx with the series of test-glasses, the fifth and sixth columns give a comprehensive statement of the influence of spectacles on the acuteness of vision. We see that spectacles weaker than number ten have but a slight influence on the distance in which the different types should be read, so that we may fairly neglect it. Stronger glasses than No. 10 have a notable influence on the distance in which the type ought to be read. This influence, however, is not so great as might perhaps be an-

ticipated, since of strongest convex glasses No. 2 requires only one and a half of the distance indicated by the number of type, No. 4 nearly $\frac{5}{4}$ of it, etc., whilst concave glasses No. 2 require only $\frac{3}{4}$ of the distance stated in the number of type, in order to let visual acuteness appear normal.

I think it is not practical to change anything in our accustomed annotations of visual acuteness. But when it is of importance to judge exactly of the acuity of vision, we may refer to the above table which will in a moment give us the correction to be made in our annotations. Say, for instance, a myopic eye can read with number two Sn. xx at 15′, then we would note it as follows: $M\frac{1}{2}$, $S\frac{15}{xx}$. A look at column the sixth of our table will show us immediately that S in this case is not $\frac{3}{4}$, but 1. The use of the table for reference appears to me so simple, that I think it unnecessary to give any further examples.

(B.) INFLUENCE OF SPECTACLES ON THE APHAKIAL EYE.

The optical system of the *aphakial eye*—which means an eye whose crystalline lens has been removed, or dislocated, or absorbed—is essentially different from that of the emmetropic eye. As clear vision in aphakial eyes can only be brought about by the help of strong convex glasses, I shall now proceed to investigate what influences such glasses exert on the optical system and visual acuteness of aphakial eyes. In noting, at the present day, the results of our cataract-operations, we

do no longer content ourselves by the general expressions that good or useful vision was obtained, or even that sight was regained, but we test the acuteness of vision in quite as rigid a manner as we do in ordinary eyes. To know the alterations which spectacles produce in aphakial eyes, is, therefore, not merely of theoretical, but of practical interest.

I shall determine the optical constants of armed aphakial eyes in the same manner as I did those of armed emmetropic eyes.

The *optical constants of the unarmed aphakial eye* which constitute the second system, are the following:—

ϕ_1, the first focal distance, is = 23,692 mm.

ϕ_2, the second focal distance, = 31,692 mm.

Both the principal points coincide, and are situate in the apex of the cornea.

Both the nodal points coincide likewise, and are situate in the centre of curvature of the anterior surface of the cornea, namely, 8 mm. behind its apex.

These values are borrowed from *Listing's* diagrammatic eye, in conformity with our former inquiries into the optical constants of armed emmetropic eyes. The first optical system is represented by the convex glass lens, the principal and nodal points of which, here too, may be assumed with sufficient accuracy to coincide with its optical centre. We admit that the latter is placed 12 mm. in front of the eye. This, therefore, is the mutual distance—called *d*—of the principal points of the first and second systems.

Helmholtz's formula 11*d*, $h_1 = \frac{d\,f}{d - \phi_1 - f}$, will serve to calculate the position of the first principal point of the compound system in front of the first principal plane of the first single system. Applied to lens + 3, that is, of 81,21 mm. of positive focal distance, it will result in

$$h_1 = \frac{12 \times 81{,}21}{12 - 23{,}692 - 81{,}21} = -\,10{,}485 \text{ mm.},$$

which means that the first principal point of the compound system lies 10,485 mm. *behind* the glass. Since the latter is placed 12 mm. in front of the cornea, the first principal point of the compound system lies 1,515 mm. in front of the cornea.

Formula 11*e*, $h_2 = \frac{d\,\phi_2}{d - \phi_1 - f}$, determines the position of the second principal point of the compound system behind the cornea. It results for lens + 3 in $h_2 = -\,4{,}0917$ mm. The − sign signifies that h_2 lies in front of the cornea, and, as follows from the position of h_1, 2,5767 mm. before the first principal point of the compound system. The latter number denotes at the same time the distance between both the principal points, therefore also that between both the nodal points of the compound system. For lens + 3, therefore, $H_1\,H_2 = K_1\,K_2 = 2{,}5767$ mm.

The position of the *first focal point* of the compound system in front of the optical centre of the glass lens is obtained by formula 11*a*, $a_1\,t_1 = \frac{(d - \phi_1)\,f}{d - \phi_1 - f}$. For lens + 3 this is found by calculation = 10,216 mm. If we add 12

mm. as the distance of the glass from the cornea, we obtain the position of the first focal point of the compound system in front of the cornea, namely, 22,216 mm. Since, however, the first focal length is reckoned from the first principal point, we must deduct 1,515 mm. from that quantity, and we obtain the anterior focal length of the compound system $F_1 = 20,701$ mm.

The position of the *posterior focal point* behind the second principal plane of the second system—in our case the anterior surface of the cornea—is determined by formula 11*b*, $\alpha_2\, t_2 = \frac{(d - f)\,\phi_2}{d - \phi_1 - f}$. By inserting the proper values, we find for lens + 3 $\alpha_2\, \tau_2 = 23,599$ mm. It is evident that this number represents at the same time the length of the AXIS OF AN APHAKIAL EYE which sees at distance best with + 3. As, however, the posterior focal length is measured, not from the cornea, but from the second principal point, we must add to this quantity 4,0917 mm., the distance in which the second principal point of the compound system is situate in front of the cornea. Thus we obtain $F_2 = 27,691$ mm.

The positions of the two *nodal points* of the compound system are easily found out by the following considerations:—The distance between the second nodal and the posterior focal points is equal to the first focal length. Therefore $F_2 - F_1 = H_2\, K_2$, that is, the distance between the second principal and second nodal points, which is also equal to $H_1\, K_1$, the distance between the first principal and first nodal points. For lens + 3 H_1K_1, or H_2K_2, is equal

to 6,990 mm. Since the first principal point lies 1,515 mm. before the cornea, we must deduct this quantity from 6,990, to find the position of the first nodal point behind the cornea. We obtain 5,475 mm. The position of the second nodal point is found in a similar way by deducting from 6,990 mm. the distance of the second principal point from the cornea, which amounts to 4,092 mm. We obtain K_2 lying 2,898 mm. behind the apex of the cornea.

In this way all the optical constants of an aphakial eye armed with + 3 are determined.

Let us now inquire *what influence spectacle glasses exert on the visual acuteness of aphakial eyes.*

We assume that the eye, before it was deprived of its crystalline lens, possessed normal visual acuity. The position of its retina, that is, the length of its antero-posterior axis, can be determined, after its lens has been removed, by formula 11*b*, as we have seen. Since we know the optical constants in the aphakial state, we can calculate the

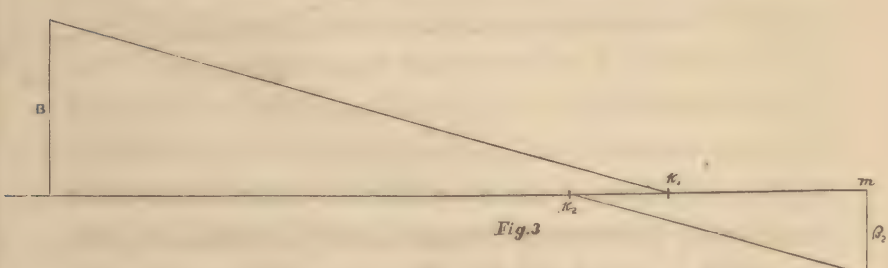

Fig. 3.

size of the retinal image of any visual object. B, in Fig. 3, may represent a small remote object which the apha-

kial eye, armed with + 3, is able to see distinctly. The one of its end-points may be situate on the optical axis of the eye. The line of direction of its other end-point is, in its course through the air, directed to the first nodal point K_1, and passes, in its course within the vitreous body, through the second nodal point K_2, while remaining parallel to its first section in the air. Thus the retinal image β_2 is defined. If we now imagine the same eye to be still in possession of its normal crystalline lens, we may draw in it the retinal image of the same object seen in the same distance. Since cornea and lens are assumed to be normal, the optical constants of *Listing's* diagrammatic eye may be used for the determination of the retinal image. Fig. 4 may illustrate this. To find out the

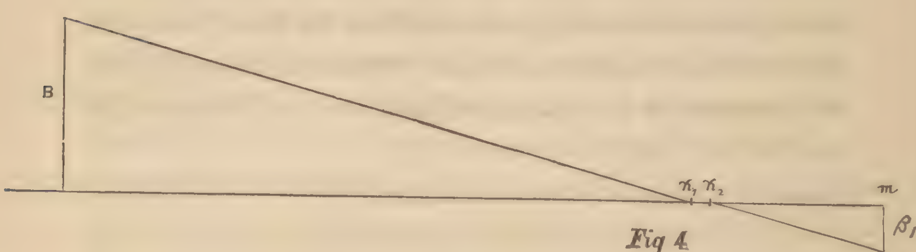

FIG. 4.

magnifying effect of the glass lens, we have to compare the sizes of the retinal images β_2 and β_1 formed, in both eyes, of the same object B. The triangles formed by the retinal images and their connecting lines with the posterior nodal points being similar to each other, the sizes of both images are to each other as their distances from the

second nodal points. $\frac{\beta_2}{\beta_1} = \frac{m\ K_2}{m\ \varkappa_2}$. If we attribute to β_1 the value 1, then $\beta_2 = \frac{m\ K_2}{m\ \varkappa_2}$. The quantity mK_2 is known, and equal to the anterior focal length F_1 of the lensless eye when armed with + 3. The quantity $m\varkappa_2$ may be called ϕ, and determined as follows. We found the axis of this eye equal to 23,599 mm. The posterior nodal point is situate 7,373 mm. behind the cornea. ϕ, therefore, is equal to 23,599 − 7,373 = 16,326 mm. We obtain, consequently, $\beta_2 = \frac{F_1}{\phi} = \frac{20{,}701}{16{,}326} = 1{,}2758$. This is what we have called the co-efficient of the magnifying effect of the glass lens. The distance at which any number of Snellen's test-types ought to be read by a lensless eye, when armed with + 3 and endowed with normal visual acuteness, is obtained by multiplying this co-efficient with the number of the type, for instance, No. xx should be read in 20 × 1,2758 = 25,52 feet.

In this consideration we have presupposed that the lines of direction emanating from the end-points of the same object, which has to remain at the same distance, are parallel, and this supposition may be made with sufficient accuracy. The letters of Sn. xx are 9,5 mm. high, they are seen at a distance of 20′, that is, 6496,9 mm. The first nodal point of the emmetropic eye lies 6,957 mm. behind the cornea, that of the aphakial eye, when armed with +3, lies 5,475 mm. behind the cornea. If from an elevation of only 9,5 mm. above a straight

basal line, other straight lines are drawn to two points of the same basal line at a distance of 6497 mm. from the point of origin, and only 0,3 to 3,0 mm. from each other, these lines will be sufficiently parallel to each other for all ordinary purposes. To satisfy myself of this fact, I have calculated the visual angles formed in emmetropic eyes and armed aphakial eyes by letters of Sn. xx seen at 20′. If we call the visual angle v, its tangent will be, in the emmetropic eye, $\frac{9,5}{9503,9}$, and in an aphakial eye, when armed with +4, = $\frac{9,5}{6503,0}$. The logarithms of the tangents of these angles differ only in the fifth decimal, and show in both cases an angle of five minutes. This angle remains the same also for the strongest lens, + 1½, that may ever be put before an aphakial eye. The logarithms of the tangent of its visual angle and that of the emmetropic eye differ by 0,00022, whilst the difference of the logarithms of the tangents of an angle of 5 minutes and 0 second, and those of an angle of 5 minutes and 1 second is 0,00134. From the foregoing considerations it ensues *that the movement of the first nodal point by spectacle glasses exerts no appreciable influence on the size of the smallest visual angle* as used in our common test-types, since its greatest movement, produced by + 1½, causes a change in the size of the visual angle not exceeding ⅙ of a second.

Thus far I have shown, in a general way, and illustrated by an example, what alterations are brought about in the optical system of aphakial eyes armed with spec-

tacles. I have demonstrated, moreover, what influence spectacles have on visual acuteness when the latter is tested in the manner now in general practice. Since both the changes of the optical constants and of visual acuteness deserve to be known, I have calculated them for the usual cataract glasses; and collected them, for the sake of reference, in the subsequent table.

The letters at the heads of the columns have the following meaning:—

No = focal length of glass in Paris inches.

F_1 = first focal length of aphakial eye armed with lens named in first column.

F_2 = second focal length of compound system.

Ax = Axis of aphakial eye requiring for distant vision lens indicated in first column.

$H_1\ K_2$ = distance between first principal and first nodal points.

$H_1\ H_2 = K_1\ K_2$ = mutual distance of principal or nodal points.

H_1 = position of first, and H_2 of second principal point behind the cornea. A − sign indicates that they lie before the latter.

K_1 and K_2 = position of first and second nodal points behind the cornea.

Co-ef. = Co-efficient of magnifying power.

Sn. xx *in feet*, at what distance, in Paris feet, Sn. xx should be read when S = 1.

No.	F_1.	F_2.	Ax.	H_1 K_1.	H_1 H_2.
1½	18,300	24,596	17,324	6,296	4,536
1¾	19,080	25,525	19,193	6,445	3,996
2	19,485	26,063	20,286	6,578	3,646
2½	20,202	27,024	22,232	6,802	3,024
3	20,701	27,691	23,599	6,990	2,577
3½	21,089	28,210	24,637	7,121	2,254
4	21,384	28,605	25,435	7,221	2,001
5	21,809	29,172	26,586	7,363	1,632
6	22,113	29,565	27,381	7,452	1,389

No.	H_1.	H_2.	K_1.	K_2.	Co-ef.	Sn. xx. in feet
1½	— 2,736	— 7,2720	3,560	—0,976	1,8390	36,78
1¾	— 2,336	— 6,3316	4,109	0,113	1,6149	32,30
2	— 2,131	— 5,7769	4,447	0,801	1,5124	30,25
2½	— 1,768	— 4,7917	5,034	2,010	1,3595	27,19
3	— 1,515	— 4,0917	5,475	2,898	1,2758	25,52
3½	— 1,318	— 3,5730	5,803	3,549	1,2216	24,43
4	— 1,169	— 3,1700	6,052	4,051	1,1839	23,68
5	— 0,954	— 2,5864	6,409	4,777	1,1351	22,70
6	— 0,795	— 2,1843	6,657	5,268	1,0801	21,60

LARGE CYST OF THE IRIS, CURED BY OPERATION.

By H. KNAPP.

The literature of cystic tumors of the iris is yet very fragmentary. *J. W. Hulke* (Ophth. Hosp. Rep., Vol. VI., 1, p. 12) and *L. Wecker*, in his Études Ophthalmologiques (I., p. 426), and in a paper in these Archives (I., 1, p. 85), have given the fullest accounts of what is known on this subject. Since especially the clinical part of cystic tumors originating in the iris is as yet most defective, I think that the description of the following case may not prove destitute of interest and practical utility.

Cecile *Delahaye*, from Burlington, Iowa, eleven years of age, was injured, eighteen months ago, with a knife, the point of which entered her left eye just at the corneo-sclerotic juncture. The pupil became pear-shaped, the sight, for some days impaired, returned nearly as good as that of the other eye. A black, elevated spot at the seat of the wound was always visible. The eye was free from pain and annoyance. Eight months ago, however, the father observed that a thin gray membrane had formed in the eye directly under the scar, and was grad-

ually increasing in the direction of the pupil. Four months ago he perceived that a similar membrane developed itself on the other side of the pear-shaped pupil. Both were growing steadily, and slowly approached each other, until they coalesced, assuming a heart-shaped figure. The sight had been impaired, and the eye, of late, became from time to time red and painful.

The patient, a tall healthy girl, presented herself to me on the 31st of May, 1869. Her right eye was normal in appearance and functions, and had never experienced any alteration. The left showed some episcleral injection, most marked towards the nose. On the sclerotic border, a little inward from the upper end of the vertical corneal meridian, was a small bluish elevation of three millimetres in length and two millimetres in breadth (*a* Fig. 5). Through the normal cornea a

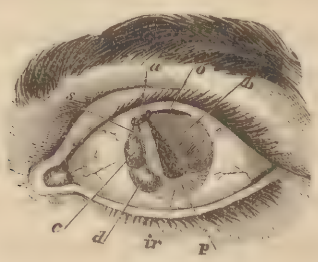

Fig. 5.

transparent cyst was, at first glance, visible, filling the upper four-fifths of the anterior chamber. It left a small piece of healthy iris, on the lower part of the chamber

(*ir*), uncovered, and about a quarter of the normal size of the pupil was free and perfectly black (*p*).

The *cyst itself* appeared as a transparent, homogeneous, somewhat grayish bag, filled with clear water. The coloboma and iris could be seen through it. The whole anterior surface of the cyst appeared to be in immediate contact with the cornea, whilst its inferior border was round, and formed an angle in the pupil (*a*). Its upper and outer part lay upon the iris, which it pushed backward (*b*). The surface of this part of the iris, visible through the cyst, displayed a grayish discoloration, but was smooth, with quite a regular pupillary edge. On the upper corneal margin there existed a small, slit-shaped iridodialysis (*o*, Figs. 5 and 6). Entirely different was that portion of the iris bordering on the inner side of the coloboma. It was very much pushed backward, and showed two cup-like depressions (*c*, *d*), each of which was confined, inferiorly, by a curved projecting ridge of iris tissue. The lower of them formed the boundary of the preserved healthy part of the iris. The surface of the depressed portion of the iris appeared dirty gray, and even black in the upper part, which also exhibited the deepest cup. The pupillary edge was elevated, forming, along the whole inner border of the coloboma, a septum (*s*) with antero-posterior direction slightly bulging towards the coloboma. Its margin did not reach the posterior surface of the cornea, but was overlapped by the outer portion of the cyst. Inward from the coloboma, especially in the upper cup, the tis-

sue of the iris appeared rarefied, and the black pigment of the uveal layer became visible through the cyst.

My opinion was that this cystic tumor had its origin in that portion of the tissue of the iris which was involved in, and attached to, the corneo-scleral cicatrix. It had first grown within that portion of the iris which lay inward from the coloboma. Its anterior wall soon projected over the anterior surface of the iris, extended, in its upper part, over the pupil and the outer portion of the iris, and became so much filled that it touched the posterior surface of the cornea, and crowded the iris and lens backward. The tumor was evidently still progressive.

All the cysts of the iris which have been recorded up to this day (about 22 in number) *were, when left untouched, destructive to the eye, and several of them even caused sympathetic inflammation of the other eye.* I therefore was convinced that nothing but an early operation could save the eye of the patient, and my opinion was confirmed by further examination.

The eye was painful to the touch, exhibited a manifest increase of tension, which remained unvariable during the four following days. $S = \frac{1}{25}$. $M = \frac{1}{14}$. The other eye was emmotropic; the O S revealed nothing remarkable in the fundus of either eye, especially no staphyloma posticum of the left. The myopia of this eye was surprising, in consideration of the fact that iris and lens were considerably pushed backward, which condition of itself evidently would have rendered the eye hyperopic.

This, however, did not take place, but just the contrary, which may be explained in the following way. The cyst pressed forcibly on the lateral portions—except the lower one—of the lens, and thereby caused a bulging of that portion of the anterior lens surface which was not covered or pressed upon by the tumor. A circumscribed augmented convexity of the anterior capsule must have been produced to such a degree as not only to counterbalance the optic effect of the retrocession of the lens, but even to cause considerable myopia.

The nature of the disease, and the painfulness, increased tension, and impaired sight of the eye, forced the unswerving conviction upon me that the eye was sure to be destroyed unless the growth of the cyst were checked. To expect this from anything else but an operation, could not be thought of. Puncture of the cyst would surely have been followed by a recurrence. The removal of the whole cyst seemed impossible without rendering the operation too perilous by the extent of the wound. I therefore concluded to take away as much of the tumor as I could without exposing the eye to a greater danger than is borne safely in ordinary operations. If a recurrence should follow, I imagined, then the incipient state of the refilling cyst would show a tumor smaller and easier to remove totally by a subsequent operation. I operated in the following way. With a broad lance-shaped knife I made an incision at the inner side of the corneo-sclerotic juncture, near the corneal margin, but within the sclerotic border. The inner portion of the

cyst, of course, was penetrated and emptied by the knife. Introducing a pair of delicate iris-forceps, and trying to seize that piece of the cyst which lay over the pupil and the outer part of the iris, I found an insurmountable obstacle in the vertical septum (*s*, Fig. 5). I therefore seized the latter by widely opening the branches of the forceps, and, after closing them, I had the pleasure of seeing the whole inner part of the iris come out. Cutting it off close to the wound produced a wide coloboma, in which none of the inner part of the iris remained behind. The condition of the eye, after the operation, is represented in Fig. 6. The uncovered part

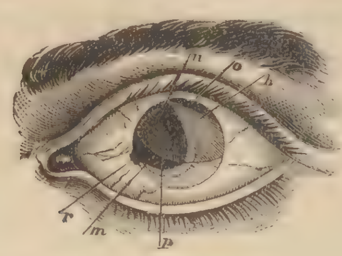

FIG. 6.

of the pupil, which before the operation had been small and triangular (*p*, Fig. 5), had enlarged to a broad stripe, reaching the inner margin of the cornea (*p*, Fig. 6). The broken wall of the outer cyst still covered the outer part of the iris (b), and its lower border (*m*, Fig. 6) stretched across the upper pupillary space nearly as far as the inner corneal margin. In seizing the septum I had caught hold of the overlapping portion of the outer

cyst, and dragged it necessarily towards the wound, in which, however, it was not involved.

A moderate degree of irritation followed the operation. Tolerably well marked circumcorneal injection, and some swelling of the border of the upper lid on the following day, were symptoms not altogether pleasant, but they were counterbalanced by the total absence of pain, and normal appearance of the lower part of the iris. I abstained, therefore, from any severer treatment. The eye recovered very rapidly. Ten days after the operation a slight protrusion of iris in the corner of the scar of the iridectomy wound was noticeable, which increased somewhat during the following days, representing a condition which we not infrequently see after large excisions of the iris in operations for glaucoma or extraction of cataract. The sight of the eye was greatly improved, the tension of the globe lessened, but in the upper part of the pupil there seemed to be a renewed and circumscribed swelling (*n*, Fig. 6) of the cyst, the walls of which, up to that time, had lain shrivelled up and flat upon the lens and outer part of the pupil, the anterior chamber having been, soon after the operation, fairly re-established. Since this swelling threatened to cause a refilling of the cyst, and in any case darkened a considerable part of the pupillary field, I decided to remove it, if possible, together with as much of the adjoining part of the iris as I could, by another outward and upward iridectomy. After having made a broad incision at the upper and outer corneal

margin, I introduced a blunt (Tyrell's) hook in front of the iris and remaining part of the cyst, as far as to bring the point of the instrument behind the inner edge of the cyst. I grasped with the hook the peripheral portion of the cyst near the point *m*, and proceeded to draw it out in the direction towards *b* (Fig. 6), together with the iris beneath it. At first the cyst followed nicely, separating itself from the capsule of the lens, but its attachment to the upper part of the primary coloboma and to the scar did not give way, so that the tissue of the cyst was ruptured, and only the middle portion of it extracted and cut off with the iris. By means of forceps and a sharp iris hook I attempted, with great care not to wound the lens-capsule, further to remove the upper and lower remnants of the cyst, but succeeded only partially. After having done this, I excised the small prolapse of iris in the corner of the first iridectomy wound (*r*, Fig 6). The operation was followed by no pain, but the globe became red, and the upper lid swelled. No remedy was administered except atropine. The eye recovered rapidly from the operation, sight improved, and the small remnants of the cyst shrivelled up, resembling patches of connective tissue. A week after the operation the very lively young patient, having been imprudent in walking, and eating more ice-cream than was good for her, felt feverish and sick, and vomited several times. She had some pain in her eye, and an abundant running of tears. I did not see her till the following day, and found the eye red again, the anterior chamber quite empty, and the

iris greenish discolored. I ordered six leeches to be put in the temple, and kept her in bed for two days, having atropine dropped into her eye every hour. The iritis at once subsided, the anterior chamber slowly refilled, the visual field, which had become densely clouded, cleared up again, and at the end of five days the consequences of this inflammatory attack had disappeared. A week later, that is, three weeks after the second, and five after the first operation, the patient returned home, her eye being in the following condition. It was still very sensitive to brilliant light. Vision $\frac{1}{10}$, having been $\frac{1}{25}$ before the first operation. The *myopia had disappeared.* She could read Sn. CC at 20′ distance, and said that concave glasses made the letters no clearer, whilst convex glasses made them blurred. F was normal, and T no longer increased. Subconjunctival vessels were still somewhat injected. The cicatrix from the first iridectomy showed again a small prolapsus iridis in the

Fig. 7.

lower corner, and there seemed to exist some tendency to cystoid protrusion of the cicatrix. The second iridec-

tomy wound was firmly united ; the outer surface of the cornea clear and sensitive; its inner surface, however, showed in its upper inner part (*c*, Fig. 7) some dark grayish spots, like connective tissue, probably the remainders of the shrivelled cyst having become attached to the cornea during the evacuation of the anterior chamber. The lower and outer portion of the iris (*ir*, Fig. 7) appeared quite normal, only the corner (*g*, Fig. 7) bordering outwardly on the coloboma was still covered by a delicate grayish membrane, being the last remnant of the cyst wall. The lens was transparent throughout, but some opacities upon the capsule had remained behind. It seemed to be somewhat pushed forward, the anterior chamber having not yet regained its natural depth. The interior of the eye could be well illuminated, but I was unable to distinguish the details of the fundus on account of the irritability of the eye.

I should have been glad to remove the last remnant of the cyst, together with the small part of iris beneath it, but at the second operation it was not possible to excise it without giving the wound such an extent as to endanger the eye. To take it away now, three weeks after the second operation, did not seem advisable either, since the endurance of the eye for further operations, as well as the patience of the little sufferer, appeared to be exhausted. Apart from this, the refilling of the cyst could not be predicted with any degree of probability. If it should occur, which was no more than a mere possibility, less supported by the analogy of similar observa-

tions than apprehended by our sympathizing care for the amiable young patient, an ultimate operation in order to take away the small remains of the cyst would not have been so perilous as either of the preceding ones.

I examined the pieces of iris and cyst which had been removed by the first operation. The iris had preserved its natural structure, showing no degeneration, but some degree of atrophy. Upon it lay the delicate cyst-wall, composed of flat, very large, polygonal epithelial cells.

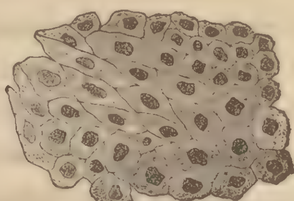

FIG. 8.

I could not make out a basement membrane between these cells and the iris, but a piece of the free wall of the cyst exhibited the parallel and winding lines characteristic of homogeneous membranes, for instance, the glassy membrane beneath the pigment epithelium of the choroid. Therefore it was evident that the *wall of the cyst consisted of a delicate homogeneous* (*glassy*) *membrane lined with pavement epithelium.* Its contents were entirely transparent and fluid, like water. They could not be gathered during the operation, although I tried to obtain them.

The origin of cystic tumors of the iris has been much discussed of late. There are three opinions on it:—

(1.) They are said to be the dilatation of pre-existing free spaces in the iris. (2.) They are regarded as new formations, a conclusive illustration of which is furnished by the highly interesting observation of *Von Graefe*, relative to a dermoid cyst in the iris containing atheromatous matter with short stiff hairs (Arch. f. Ophthalm., III., 2, p. 412, and ibidem, VII., 2, p. 39). (3.) They are supposed to develop by a process of sacculation in such a way that by adhesive inflammation, especially after penetrating wounds, the iris becomes attached to some part of the walls of the anterior chamber. If in such cases a free space between the attached parts is left, the secreted fluid will increase it to form a pouch, which by subsequent formation of a new wall will become a true cyst. This opinion, strongly advocated by *L. Wecker*, accounts best for the origin of the cyst in the case just described.

The unfavorable side of the *prognosis* of the latter depends upon the possibility that the last piece of the cyst left behind may become the starting-point of a recurrence, and besides that, in the predisposition for glaucoma in eyes with anterior synechiæ. A tendency to serous effusions is manifested in this eye by the cystoid cicatrix at the place of the primary injury, and, perhaps, by the small portion of iris involved in the lower angle of the first iridectomy wound. The large coloboma, however, and the youth of the patient, will, I suppose, counterbalance this tendency. As to the possibility of a recurrence, I think that what we know

on this subject does not speak for its probability, since iris cysts did not reappear even after simple paracentesis, or after removal of their anterior (free) wall, whilst in the case under consideration only a very small part of the cyst wall, and the iris beneath it, is left behind, but the bulk of the tumor, and all the iris with which it was connected, are taken away.

Since I wrote the foregoing, which was at the time of the patient's discharge, I have had repeated information with regard to her health. The eye has completely recovered, there is no irritability of either eye, and no cystoid protrusion of the wound has developed. The lower part of the iris is somewhat drawn upward, encroaching upon the clearest portion of the pupil; vision, however, so far restored that ordinary print can be read with the injured eye. This was the condition of the patient according to the latest information, which I received a few days ago,—seven months after the operation.

CASE OF EXTIRPATION OF A CANCROID GROWTH OF THE INNER CANTHUS AND UPPER EYELID. BLEPHAROPLASTY BY SLIDING FLAPS.

By H. KNAPP.

THE unsatisfactory results obtained in many cases of blepharoplasty by transplanted flaps of skin, due to subsequent contraction and thickening, with very unpleasant consequences, induced me, during the last few years, to cultivate more the method of the *sliding of flaps.* My experience in this direction has been so far very encouraging. Two extremely satisfactory cases I have published a short time ago, the one in the "Arch. f. Ophthalm.," XIII., p. 180, etc., and the other in the first number of the Archives of Ophthalm. and Otology, p. 139.

The following case is analogical to the two preceding ones, but offers peculiarities with regard to the mode of operation which may prove useful in the treatment of similar difficulties:—

Sea-Captain M., of Scotland, 45 years of age, healthy

and robust, observed about two years previously a small, hard, circumscribed elevation in the skin of the upper eyelid and the inner canthus. It gradually increased, was surrounded by other nodules, and constituted, at the time when he came to me, August 23d, 1869, a nodular thickening of the skin upon and above the inner canthus (see Fig. A), twelve millimetres in breadth and thirty

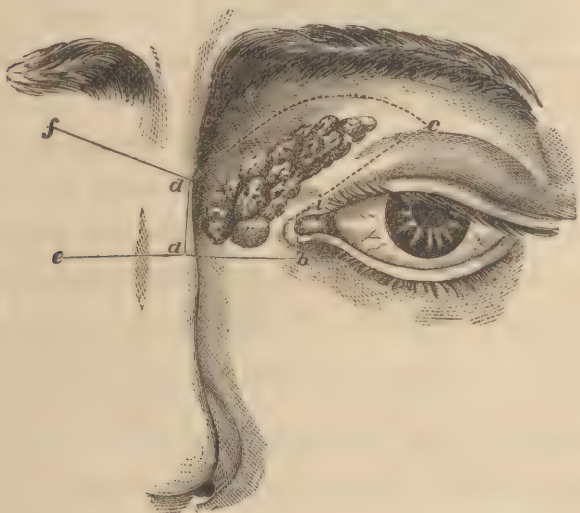

Fig. A.

in length. The tumor was felt by the exploring finger as a dense mass receding into the orbit, but without firm attachments to the bone. Since it presented all the qualities of a cancerous growth, the patient agreed at once to its removal by an operation, which advice had been already given to him by some other physicians.

I circumcised it by a curved and angular line fully

within the healthy skin (*a b c d*), and dissected it carefully and slowly through the healthy tissue of the orbit, guiding my steps always by the exploring forefinger of my left hand. The ligamentum canthi, being quite unaffected, could be spared, but above it I found the tumor penetrating into the orbit about half an inch, so that after its removal a considerable hole was visible. The inner portion of the cartilage of the upper lid had been taken away. The defect of skin which reached from below the inner canthus and the root of the nose obliquely upward and outward as far as the eyebrow, and a little beyond the middle of the upper lid, was covered by sliding flaps in the following manner:—A straight cut, *a e*, was made through the skin horizontally over the back of the nose, in prolongation of the lower border of the wound *a b*. Another straight cut, *d f*, went through the skin from the inner upper orbital angle towards the brow of the other eye. The flap comprised between these two lines was dissected from the original wound towards its basis, which lay on the other side of the nose. Next I dissected the inner portion of the lower lid, *b*, from the subcutaneous tissue of the conjunctiva, and separated, to the extent of some lines, the skin of the upper lid along the wound *b c* from the orbicularis muscle and cartilage. I then united the lower end, *a*, of the nasal flap with the inner end, *b*, of the lower lid, which caused considerable stretching of the latter and the flap. The lower border of the flap was united by silk sutures with the adjacent skin without marked puckering of the latter. Then the

inner part, *i*, of the upper lid was fastened to the opposite border of the nasal flap. The wound now looked as represented in Fig. B. A simple stitching together of the

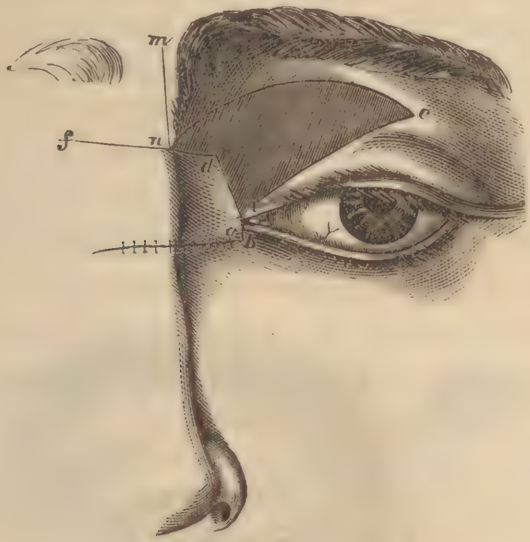

Fig. B.

upper lid and the nasal flap could not be thought of, because it would have occasioned a very disfiguring ectropion. To make a cut through the upper lid, parallel to the margin of the lid, and shifting the latter towards the nose as far as to reach the flap, was quite impracticable, because the tendon of the levator muscle must be preserved lest incurable ptosis be the consequence. For this reason the method which I have very successfully applied to the lower lid, is not applicable to the upper. To obviate both these difficulties, ectropion and ptosis, I made a vertical cut, *n m* (Fig. B), from the

inner upper angle of the wound, about three-quarters of an inch in length. Now I dissected off the skin situate above the wound, and fitted the angle *m n c* into the angular defect *d i c* (Fig. B), uniting the edge *n c* with *i c*, and the lower part of *n m* with the upper part of the vertical margin of the nasal flap. The remaining small triangular defect, *d n m* (Fig. B), was covered by loosening from its base the triangular flap of skin *m n f*, lying above the quadrangular nasal flap, and by uniting its edges with the opposite edges of the remaining triangular defect.

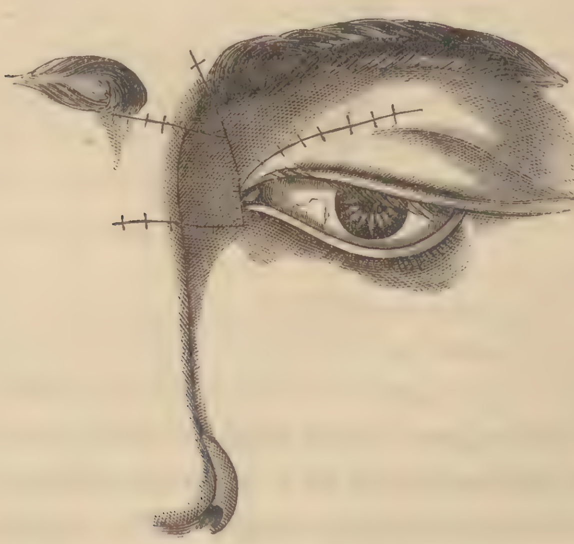

Fig. C.

In this manner the whole wound was closed, and the region of the operation had the appearance which is represented by Fig. C. Both eyelids were stretched

towards the nose, a slight degree of eversion of the inner margin of the upper lid existed, and the transplanted portions of skin, now situate over the inner canthus, stretched over a hollow space, the former seat of the orbital portion of the tumor. I considered this hollow space a favorable condition, presupposing that the cicatricial tissue which was to fill it up would draw the skin bridging loosely over it, backward into the orbit. This expectation was fully realized. There was but trifling suppuration in this space. The whole wound healed by first intention, and the slight degree of eversion of the inner portion of the upper lid entirely disappeared, in consequence of the retraction of the cicatrized tissue near the inner canthus. The upper lid was perfectly movable, and the palpebral fissure closed easily at will and during sleep. Epiphora was the only thing the patient had to complain of. The interference with the canaliculi and the removal of the m. compressor sacci lacrymalis were the unavoidable cause of this not very material annoyance.

About a fortnight after the operation the patient was presented to the Medical Society of the County of New York, when he was examined by the scrutinizing eyes of the most experienced surgeons of the metropolis, who pronounced the result of this blepharoplasty as the most satisfactory that could have been obtained. A week afterwards the patient went on board ship again, and, four months later, he wrote to me that his eye continued

in excellent condition, showing no disfigurement or annoyance, except simple lachrymation.

On *microscopic examination* I found in the specimen the ordinary structure of epithelioma. Its peripheral portions were very vascular, and consisted mainly of smaller epithelial cells densely interspersed with lymph corpuscles, which penetrated also in large quantities into the neighboring connective tissue of the orbit. The epithelial cells of the growth were accumulated by homogeneous juxtaposition, presenting but rarely the well-known cone-like figures. In some places the large epithelial cells were very distinctly *serrated* (Stachelzellen), and, with an immersion system, the small projecting bristles or hairs could be clearly seen not only at the border of the cells, but on their surface.

From the abundance of blood-vessels, and the infiltration of the tissue around them with lymphoid bodies, the following inference concerning the mode of development of the growth may be made: the lymphoid bodies were white blood corpuscles having transuded through the walls of the capillary blood-vessels; they, being movable, infiltrated the surrounding connective tissue, and developed in the mucous layer into epithelial cells.